MISSOURI RIVER

SIOUX CITY, IOWA TO RULO, NEBRASKA

POTAMOLOGY INVESTIGATION

MISSOURI RIVER - GAVINS POINT TO OMAHA, NEBRASKA - HISTORICAL RECORDS RESEARCH

PREPARED BY
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CORPS OF ENGINEERS
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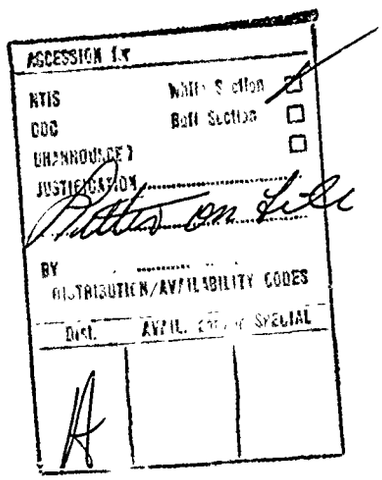
SYLLABUS

An historical data search and compilation is made to determine some of the major physical impacts which have occurred on the reach of Missouri River between Gavins Point Dam and Omaha, Nebraska, since 1950.

The chronological records of discharge ratings, channel slopes, sediment discharges, flood discharges, etc., are displayed to show their relationship to channel modifications and other physical changes made in the past 25 years. Appendices of the original data are also displayed for present and future reference.

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.



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PURPOSE

This investigation consists of reviewing historical data and determining the major physical impacts which occurred during the period 1952-1975 along the Missouri River from Gavins Point Dam to Omaha, Nebraska. The relationships of pertinent data at several locations are plotted against time to reflect the impact and magnitude of any given event at a location. The supporting data are listed in an appendix form for reference.

DESCRIPTION AND DATA

The historical data available on the Missouri River between Gavins Point Dam and Omaha, Nebraska provide a descriptive basis for uncovering the major physical impacts which have occurred in the reach since 1950 to the present time. This section of the report presents the data which are available in the reach between Gavins Point and Omaha and shows the general impact of each phenomenon. The data are divided into the following sections:

1. Construction chronology.
2. Flood events on the Missouri River and its tributaries.
3. Water temperature changes at Yankton, S. Dakota, Sioux City, Iowa, and Omaha, Nebraska.
4. Stage-discharge data at Yankton, Sioux City, Decatur, and Omaha.
5. Water surface profiles of the Missouri River.
6. Bed material sediment records.
7. Suspended sediment records.
8. Missouri River discharge hydrographs.
9. Available channel cross-section data.

Figure 1 is a reference map of the Missouri River in the vicinity being studied including the major tributaries. Table 1 gives the river mileage

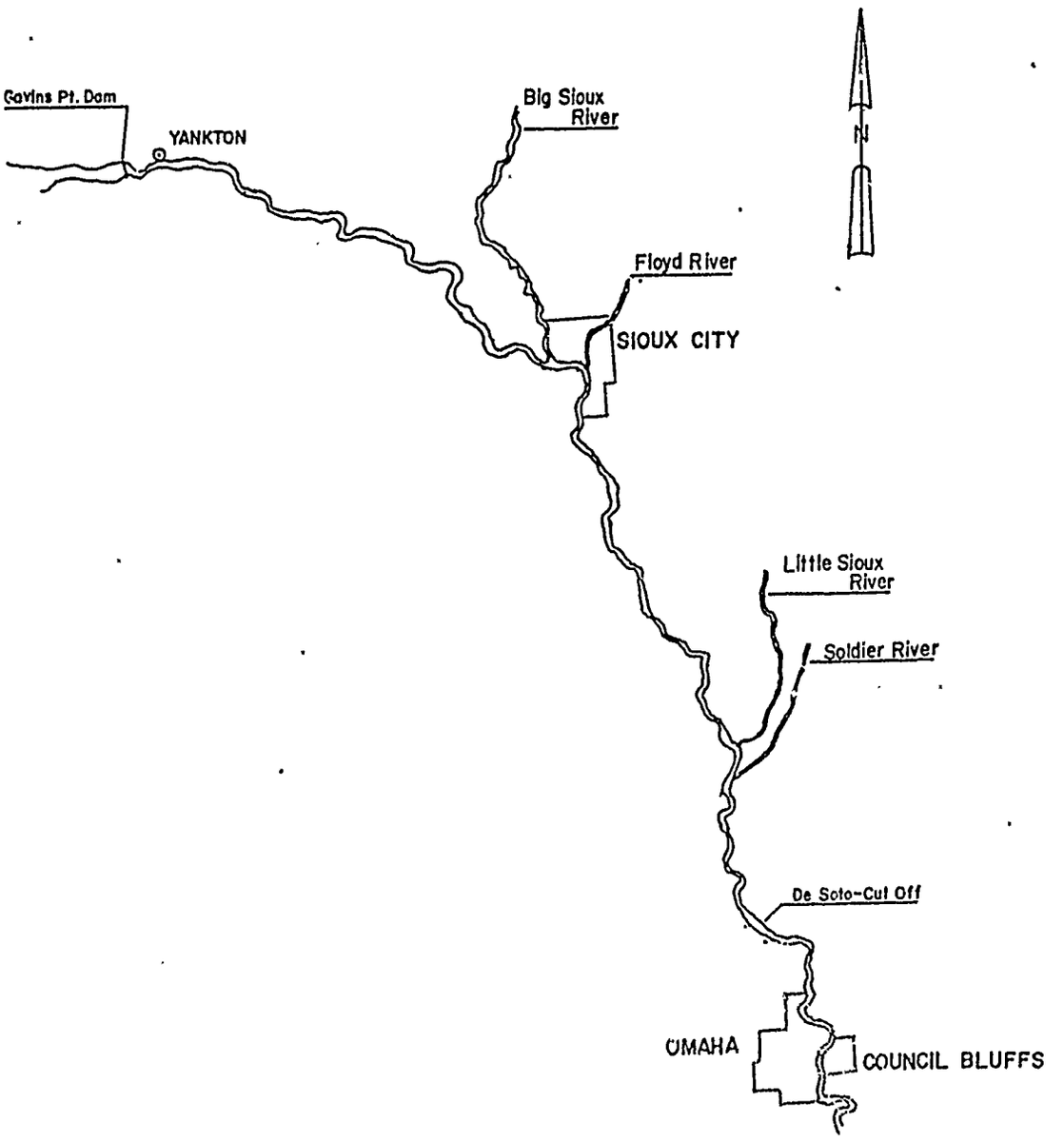


FIGURE 1. MISSOURI RIVER STUDY REACH

Table 1. Missouri River Mileage Table: Gavins Point, South Dakota, to Rulo, Nebraska

	1960 MILEAGE	1941 MILEAGE	1890 MILEAGE
GAVINS POINT DAM	811.05	846.5	
YANKTON, SO. DAK., HWY.BR.	805.76	840.4	897.3
JAMES RIVER	797.50	834.6	891.3
BOW VALLEY CREEK	787.58		
VERMILLION RIVER	772.00	806.1	856.1
ELK POINT, SO. DAK.	757.80	790.1	843.1
PONCA STATE PARK	753.70	781.6	838.8
CHAMPLIN OIL & REFINING CO., SUB. PIPELINE CROSSING	753.18		
CHAMPLIN OIL & REFINING CO., PIPELINE BR.	752.57		
NORTHERN NAT. GAS CO., SUB. PIPELINE CROSSING	752.41		
AOWA CREEK	745.36		
BIG SIOUX RIVER	734.23	761.9	810.0
SIOUX CITY, IA., HWY. BR.	732.31	760.0	807.5
NORTHWESTERN BELL TELEPHONE CO., SUBMARINE CABLE	732.30		
FLOYD RIVER (NEW MOUTH)	731.16		
SIOUX CITY, IA., C. & N.W. R.R. BR.	730.53	778.2	805.7
SO. SIOUX CITY, NEBR., AERIAL TRANSMISSION LINE	730.00		
SIOUX CITY, IA., NORTHERN NAT. GAS BR.	727.93		
DAKOTA CITY, NEBRASKA	725.81	753.6	801.0

Table 1: Missouri River Mileage Table: Gavins Point, South Dakota, to Rulo, Nebraska (Cont.)

	1960 MILEAGE	1941 MILEAGE	1890 MILEAGE
OMADI CREEK	720.39		
IOWA POWER & LIGHT CO., AERIAL POWERLINE CROSSING	717.36		
BLACKBIRD CREEK	698.66		
DECATUR, NEBR., HWY. BR.	691.04		
ELM CREEK	690.98		
DECATUR, NEBRASKA	690.90	716.9	744.7
GREAT LAKES PIPELINE CO.	689.83		
SOCONY VACUUM SUBMARINE PIPELINE CROSSING	689.50		
MONANA-HARRISON DITCH	670.00		
LITTLE SIOUX RIVER	669.17	693.5	721.8
TEKAMAH DIVERSION	663.83		
SOLDIER RIVER	663.97	687.7	715.2
HERMAN DIVERSION	659.00		
BLAIR, NEBR., C. & N.W. R.R. BR.	648.30	670.4	694.6
BLAIR, NEBR., HWY. BR.	648.27	670.4	694.6
FISH CREEK	648.00		
MOORES CREEK	640.85		
BOYER RIVER	635.21	651.0	678.9
HONEY CREEK	632.91		
OMAHA DISTRICT SERVICE BASE	626.81		
NORTH OMAHA (MORMON) HWY. BR.	626.48		
FLORENCE, NEBR.	626.07	642.0	670.3

Table 1. Missouri River Mileage Table: Gavins Point, South Dakota, to Rulo, Nebraska (Cont.)

	1960 MILEAGE	1941 MILEAGE	1890 MILEAGE
PIGEON CREEK	621.88		
OMAHA, NEBRS., I.C. R.R. BR.	618.33	634.4	662.2
NATIONAL COOPERATIVE REF. ASS'N., SUB. PIPELINE CROSSING	617.00		
AMERICAN TEL. & TEL. CO., SUBMARINE CABLE	615.92		
OMAHA, NEBR., AK-SAR-BEN HWY. BR.	615.89	632.0	659.8
FARM CROPS CORP., 16" WATER LINE	615.5		
OMAHA, NEBR., U.P. R.R. BR.	615.21	631.4	659.1
SOUTH OMAHA, HWY. BR.	612.21	628.5	655.9
O.P.P.D. AND IOWA POWER & LIGHT CO., AERIAL TRANSMISSION LINE	610.55		

of the reach being studied as measured in 1890, 1941, and 1960. Following is a description of the data gathered in this study.

CONSTRUCTION CHRONOLOGY

The period from 1952 to 1962 was a major construction period on the Missouri River between Ponca and Omaha, Nebraska. The mileage between miles 619 and 732.3 (1960 mileage) which was 113.3 miles in 1960 had been 125 miles in 1941. This is an 11.7 mile shortening in the reach between Omaha and Sioux City in a period of 20 years with most of the reduction in the 1952 to 1962 construction period. Table 2 shows a cursory history of channel realignment between Sioux City and Omaha.

Another important construction feature leaving an impact on the Missouri River was the construction of dams on the main stem of the river. Table 3 gives the history of dam construction on the Missouri River. All dams except Fort Peck influenced the river between Yankton and Omaha during the period since 1950. The most influential was Gavins Point Dam above Yankton, S. Dakota which will be discussed later in the flood, hydrograph, and sediment sections.

A large number of structures such as dikes and revetments were built between 1950 and the present. Table 4 gives the number of structures built since 1950 as determined from the Project Maps. Many of these structures are still in use, however some have been stranded due to realignment of the channel. The large increase in the number of structures indicates the extensive channel stabilization efforts made during the period since 1950.

FLOOD EVENTS

The records of yearly peak flows for the Missouri River at Yankton, Sioux City, and Omaha as well as the main tributaries are shown in Tables 5 through 11. The yearly mean discharges are included to show the amount of flow passing through the Missouri river main stem. The records are from USGS Water Supply Papers 1729, 1730, 1917, 1918, 2117, and 2118.

WATER TEMPERATURE RECORDS OF THE MISSOURI RIVER

The available water temperature data on the Missouri River at Yankton, Sioux City, and Omaha are

BEND (downstream from Sioux City)	DATE OF COMPLETED REALIGNMENT
Upper & Lower Sioux	Alignment essentially the same in 1950 as now. Channel narrowed 1962-65
Floyd	Same as above
Upper Dakota	Present alignment completed by 1959
Lower Dakota	Present alignment completed by 1959
Omadi	Flow established in present channel in 1961
Upper Browers Lower Browers	The proposed realignment combined the 2 bends into one as of 1954. This alignment was completed in 1959
Snyder	Flow established in present channel in 1961
Upper Glovers Lower Glovers	Combined to one bend - flow established in present channel in 1962
Winnebago	Flow established in 1962
Upper Omaha Mission Middle Omaha Mission Lower Omaha Mission	Little alignment change made. Flow through present alignment began in 1959
Upper Manona Middle Manona Lower Manona	Changed to Upper & Lower Manona in 1954. Diversion completed in 1957

TABLE 2. CHANNEL ALIGNMENT HISTORY BETWEEN SIOUX CITY & OMAHA

BEND (downstream from Sioux City)	DATE OF COMPLETED REALIGNMENT
Upper Blackbird Lower Blackbird	Changed and diverted to only one, Blackbird bend, in 1957
Tieville	Flow established in 1955
Upper Decatur	Flow established in 1955
Middle Decatur	Flow established in 1961
Lower Decatur	Flow established in 1962-1963
Upper Louisville	Flow established in 1965
Lower Louisville	Flow established in 1966
Upper Blencoe Middle Blencoe Lower Blencoe	Present alignment essentially done by 1960. Some structures added since 1960.
Upper Little Sioux Reach Middle Little Sioux Reach Lower Little Sioux Reach	Present alignment obtained by 1959
Upper Little Sioux Middle Little Sioux Lower Little Sioux	Present alignment obtained by 1959
Bullard	Present alignment obtained in 1961
Soldier	Alignment completed in 1962
Peterson Cutoff	Alignment established in 1957

TABLE 2. CHANNEL ALIGNMENT HISTORY BETWEEN SIOUX CITY & OMAHA

BEND (downstream from Sioux City)	DATE OF COMPLETED REALIGNMENT
Upper Sandy Point, Middle Sandy Point, Lower Sandy Point	Made into one bend. Present alignment obtained by 1959
Tysons Bend	Alignment established by 1959
California Cutoff	Completed in 1958
Upper Blair, Lower Blair	Combined with part of DeSoto bend to form Blair-DeSoto bend in 1960
DeSoto Cutoff	Cutoff made in 1960
Bertrand-Harrison	Eliminated in 1960
Upper Calhoun, Middle Calhoun, Lower Calhoun	Essentially same alignment since 1950
Boyer bend to Manawa bend	Alignment has been stable since 1950

TABLE 2. CHANNEL ALIGNMENT HISTORY BETWEEN SIOUX CITY & OMAHA

Completion Date	Dam and Location	Capacity A.F.
1940	Fort Peck near Glasgow, Montana	18,900,000
1953	Fort Randall near Lake Andres, S. Dakota	5,700,000
1955	Garrison Dam near Garrison, N. Dakota	24,200,000
1955	Gavins Point near Yankton, S. Dakota	520,000
1962	Oahe Dam near Pierre, S. Dakota	23,500,000
1964	Big Bend Dam near Chamberlain, S. Dakota	1,910,000

TABLE 3. MISSOURI RIVER DAM CHRONOLOGY

Between Structure	Year 1950	1960	1970
800.0-810	64	112	155
790-800	16	32	69
780-790	11	26	50
770-780	17	16	49
760-770	33	45	108
750-760	22	44	74
740-750	44	57	133
730-740	36	44	98
720-730	39	66	146
710-720	32	38	91
700-710	44	81	136
690-700	38	47	102
680-690	52	61	80
670-680	47	84	135
660-670	47	76	119
TOTAL	542	829	1545

Table 4. Number of Structures in Selected Reaches

Year	Maximum Discharge, cfs		Mean Discharge, cfs
1950			
51	13,400		2886
52	12,100		2291
53	7,938		1192
54	21,060		1262
55	8,600		584
56	2,782		124
57	6,762		395
58*	3,000		125
59	14,000		533
1960	23,900		1251
61	14,000		1141
62	24,400		1891
63	19,400		729
64	13,200		424
65	27,100		1625
66	6,500		746
67	16,900	(14,500)	688
68	3,020		167
69	20,300	(13,900)	2217
1970	4,580		681
71	26,000		1644
72	5,630		807
73	10,400		1620
74	5,440		1185

*Records previous to 1958 include diversions into Monona - Harrison ditch.

TABLE 5. YEARLY MAXIMUM AND MEAN DISCHARGE.

LITTLE SIOUX RIVER; NEAR TURIN, IOWA

Year	Maximum Discharge, cfs	Mean Discharge, cfs
1951	134,000	33,100
52	480,000	42,730
53	112,000	29,260
54	38,600	23,160
55	38,500	22,340
56	47,000	23,370
57	38,600	18,940
58	35,300	19,720
59	33,900	20,080
1960	34,700	17,520
61	31,800	19,470
62	35,900	14,490
63	33,800	20,550
64	34,400	20,940
65	35,000	20,290
66	35,800	25,420
67	39,600	25,000
68	41,200	28,080
69	56,000	30,580
1970	50,000	32,130
71	52,500	36,300
72	54,500	38,240
73	51,200	29,630
74	37,400	27,250

TABLE 6. YEARLY MAXIMUM AND MEAN DISCHARGE.

MISSOURI RIVER AT YANKTON, S. DAKOTA

Year	Maximum Discharge, cfs	Mean Discharge, cfs
1951	152,000	37,830
52	441,000	47,250
53	109,000	31,280
54	51,300	24,870
55	56,200	22,250
56	38,900	23,640
57	36,200	19,770
58	39,500	20,150
59	33,600	20,610
1960	101,000	21,390
61	32,700	20,880
62	71,600	20,030
63	34,400	21,210
64	37,400	21,760
65	35,600	22,650
66	38,200	27,420
67	37,100	26,430
68	38,300	28,250
69	77,700	34,270
1970	51,200	33,510
71	69,800	38,320
72	55,700	40,750
73	54,100	32,230
74	40,000	28,110

TABLE 7. YEARLY MAXIMUM AND MEAN DISCHARGE

MISSOURI RIVER AT SIOUX CITY, IOWA

Year	Maximum Discharge, cfs	Mean Discharge, cfs
1951	152,000	43,050
52	396,000	49,150
53	112,000	33,350
54	87,400	26,560
55	51,500	23,800
56	42,600	24,040
57	59,000	20,490
58	45,400	20,790
59	57,000	21,520
1960	120,000	23,800
61	41,700	22,790
62	115,000	24,270
63	61,700	22,840
64	68,900	22,740
65	69,800	25,730
66	61,800	28,480
67	68,400	28,010
68	53,000	28,510
69	100,000	37,620
1970	51,600	34,350
71	79,700	40,260
72	66,800	42,300
73	58,600	35,220
74	47,900	30,170

TABLE 8. YEARLY MAXIMUM AND MEAN DISCHARGE

MISSOURI RIVER AT OMAHA, NEBRASKA

Year	Maximum Discharge, cfs	Mean Discharge, cfs
1951	28,800	1,822
52	33,000	2,090
53	21,800	1,141
54	21,700	1,093
55	4,940	312
56	1,840	191
57	19,400	728
58	1,120	238
59	8,430	242
1960	49,500	1,402
61	9,050	560
62	54,300	2,230
63	1,650	398
64	2,540	307
65	21,000	1,180
66	16,500	630
67	5,300	543
68	635	125
69	80,800	2,489
1970	7,380	822
71	6,900	734
72	10,100	1,251
73	12,100	1,061
74	1,830	348

TABLE 9. YEARLY MAXIMUM AND MEAN DISCHARGE

BIG SIOUX RIVER AT AKRON, IOWA

Year	Maximum Discharge, cfs	Mean Discharge, cfs
1951	23,000	807
52	19,000	594
53	11,300	265
54	17,700	209
55	8,450	163
56	7,440	59
57	23,600	154
58	17,400	147
59	13,100	170
1960	10,200	283
61	14,800	231
62	12,400	539
63	7,800	270
64	19,600 (14,200)	240
65	19,400 (13,600)	464
66	3,450	220
67	15,200	212
68	16,000	98
69	9,900	460
1970	1,840	122
71	17,300	267
72	13,400	317
73	10,700	744
74	11,400	594

TABLE 10. YEARLY MAXIMUM AND MEAN DISCHARGE.

BOYER RIVER AT LOGAN, IOWA

Year	Maximum Discharge, cfs		Mean Discharge, cfs
1950	22,500		
51	20,400		320
52	17,500		271
53	7,860		133
54	15,200		113
55	3,890		59
56	2,880		27
57	9,000		44
58	5,260		61
59	8,060		69
1960	5,580		123
61	3,480		103
62	15,500		240
63	12,000		150
64	15,300		113
65	12,000		211
66	3,900		84
67	12,200	(12,100)	118
68	10,600		50
69	6,980		162
1970	2,710		57
71	7,880		126
72	3,640		94
73	2,840		194
74	2,770		167

TABLE 11.YEARLY MAXIMUM AND MEAN DISCHARGE.

SOLDIER RIVER AT PISGAH, IOWA

shown in Tables 12, 13, and 14. The records at Yankton, S. Dakota are taken from the records of the Environmental Protection Agency. The temperatures at Sioux City, Iowa are from USGS discharge measurements taken since 1950. The Omaha data comes from USGS measurements from 1950 to 1954 and since then from the Omaha Metropolitan Utilities District pumping station at Florence. The original data are displayed in Appendix A.

STAGE-DISCHARGE RELATIONSHIP OF MISSOURI RIVER AT YANKTON, SIOUX CITY, DECATUR, AND OMAHA

Rating curves for the Missouri River have been prepared by the USGS at Yankton, S. Dakota, Sioux City, Iowa, and Omaha, Nebraska. Discharge measurements have been taken at Decatur, Nebraska, however the USGS did not prepare rating curves at this location. The rating curves used by the USGS over the years at Yankton, Sioux City, and Omaha are shown in Appendix B. Also, some average yearly curves for Decatur are shown. Appendix B includes the rating tables and the summary tables of discharge measurements taken since 1950.

The general trends in the stage-discharge rating curves at Yankton, Sioux City, and Omaha as taken from the USGS records are shown in figure 2.

Figure 3 indicates the trends of the tailwater ratings below Gavins Point Dam as determined by the Army Corps of Engineers, Omaha District for the time period 1950 to present.

WATER SURFACE PROFILES

The profiles of the water surface of the Missouri River between Gavins Point Dam and Omaha for essentially constant discharge have been taken for a period of years. Figure 4 is a summary of the slopes for 2 reaches, i.e. between Gavins Point and Sioux City and between Sioux City and Omaha. The available data are displayed in Appendix C and can be broken down to smaller reaches depending upon the information desired.

BED MATERIAL SIZES

The yearly average size of bed material of the Missouri River at Yankton, S. Dakota, Sioux City, Iowa, and Omaha, Nebraska is shown in Table 15 for the years of available record. The actual bed sample

Year	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1958	37	37	38	49	60	67	74	77	70	59	48	36
1959	34	35	38	46	73	71	74	78	68	54	38	36
1960	33	33	32	42	60	69	75	75	73	57	45	34
1961	35	35	39	44	54	70	74	76	68	52	42	39
1962	37	37	37	42	63	69	76	76	66	59	45	38
1963	34	38	38	50	59	70	77	75	71	65	47	37
1964	39	39	43	45	56	68	77	69	66	54	46	40
1965	38	39	38	43	59	68	76	75	61	55	45	37
1966	33	34	36	45	53	67	78	74	69	55	41	34
1967	33	34	39	45	55	65	72	73	68	55	42	35
1968	33	34	38	47	55	71	73	74	66	56	41	35
1969	--	--	32	50	56	64	74	73	--	48	--	--
1970	33	34	34	42	59	68	75	74	65	55	39	--
1971	--	--	35	45	--	--	73	74	68	59	49	42
1972	34	33	37	43	52	66	72	--	67	--	47	35
1973	--	--	37	47	58	--	73	74	--	--	45	--
1974	35	35	36	46	60	--	--	73	65	56	45	33
1975	36											

Water Temperature (^{o}F) of Missouri River - Yankton, S. Dakota

TABLE 12

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1949										51	41	36
1950	32	32	33	36	54	70	71	73	66	55	38	32
1951	32	32	32	44	63	67	74	72	52	52	36	38
1952	32	32	32	43	64	73	78	75	68	45	40	32
1953	32	32	35	45	58	71	75	73	68	54	40	35
1954	32	32	36	49	51	72	78	75	70	56	42	33
1955	34	32	33	57	68	72	81	80	67	59	35	32
1956	32	32	36	45	65	72	75	78	69	58	43	37
1957	32	33	39	49	58	69	78	77	65	54	41	33
1958	32	32	38	48	63	69	73	81	75	56	--	32
1959	32	33	39	48	56	76	75	75	66	58	40	36
1960	--	32	--	47	59	69	76	77	69	57	43	39
1961	32	--	39	46	57	71	75	72	--	55	40	35
1962	32	30	33	56	65	73	77	76	65	60	47	34
1963	33	--	41	56	--	71	--	77	--	--	42	--
1964	34	37	39	47	61	61	79	73	61	55	45	33
1965	32	32	--	55	60	71	74	79	60	53	48	34
1966	--	34	42	47	6-	67	81	71	65	55	39	34
1967	34	--	38	51	53	65	75	73	63	53	40	33
1968	--	33	42	48	58	67	75	76	65	55	41	34
1969	--	33	33	44	60	65	73	75	70	50	41	35
1970	32	34	33	44	63	71	76	74	65	55	41	36
1971	--	34	36	49	57	71	74	74	68	57	42	34
1972	32	33	39	47	58	69	73	74	66	53	41	36
1973	34	33	42	48	59	70	74	75	65	57	40	32
1974	34	33	38	47	60	68	76	70	63	54	45	34
1975	34	33	38	43	60	65						

Water Temperature (^{o}F) of Missouri River - Sioux City, Iowa

Data from USGS Discharge Measurements - form 207

TABLE 13

Year	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1949										56	43	33
1950	32	32	35	44	57	69	74	74	68	60	36	33
1951	42	32	33	41	62	69	76	74	63	54	35	36
1952	32	32	34	46	62	73	74	74	63	46	42	32
1953	32	33	39	46	55	73	76	75	66	57	45	35
1954	32	33	37	54	59	73	80	75	69	56	43	33
1955	33	32	34	54	66	71	81	81	68	57	39	32
1956	33	33	36	46	58	76	78	79	68	60	43	34
1957	33	34	38	46	63	74	81	81	69	57	41	36
1958	34	33	38	51	64	70	75	79	71	57	45	33
1959	33	33	35	49	62	73	76	80	68	53	38	35
1960	33	33	33	50	62	69	77	76	71	57	42	33
1961	32	32	37	46	58	72	76	76	65	55	41	34
1962	32	33	33	46	65	71	76	75	67	58	43	32
1963	32	32	38	52	61	73	79	77	71	65	46	33
1964	32	32	38	47	64	71	79	75	67	55	45	32
1965	32	32	32	45	64	71	78	77	61	55	46	34
1966	32	32	39	47	59	71	77	74	68	54	40	33
1967	32	32	38	51	56	68	76	75	67	54	41	33
1968	32	32	40	49	57	71	76	75	68	55	42	34
1969	32	32	33	49	51	67	78	79	70	55	42	34
1970	32	32	36	47	63	73	77	76	68	55	41	33
1971	32	32	32	50	58	73	76	75	67	59	43	33
1972	33	33	38	48	60	71	76	75	69	54	41	32
1973	32	33	41	49	60	72	79	78	68	59	44	34
1974	33	36	41	50	63	72	77	74	65	56	45	33
1975	32	32	35	45	63							

Water Temperature (^{o}F) of Missouri River - Omaha

1950-1954 From USGS Discharge Measurements - form 207

1955- From records of Metropolitan Utilities District Florence Pumping Station

TABLE 14

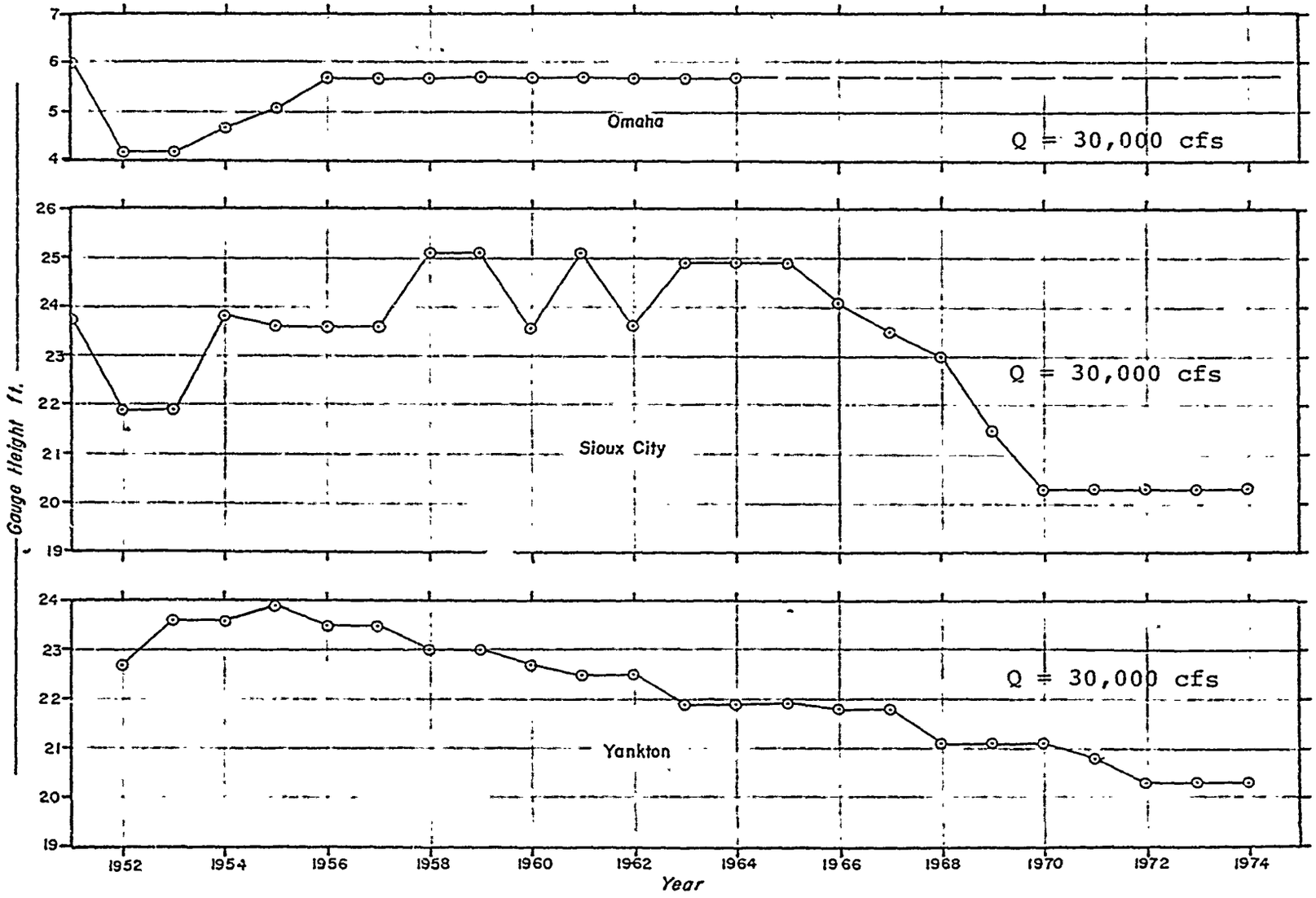


FIGURE 2. STAGE DISCHARGE RELATIONSHIP TRENDS AT OMAHA, SIOUX CITY, AND YANKTON.

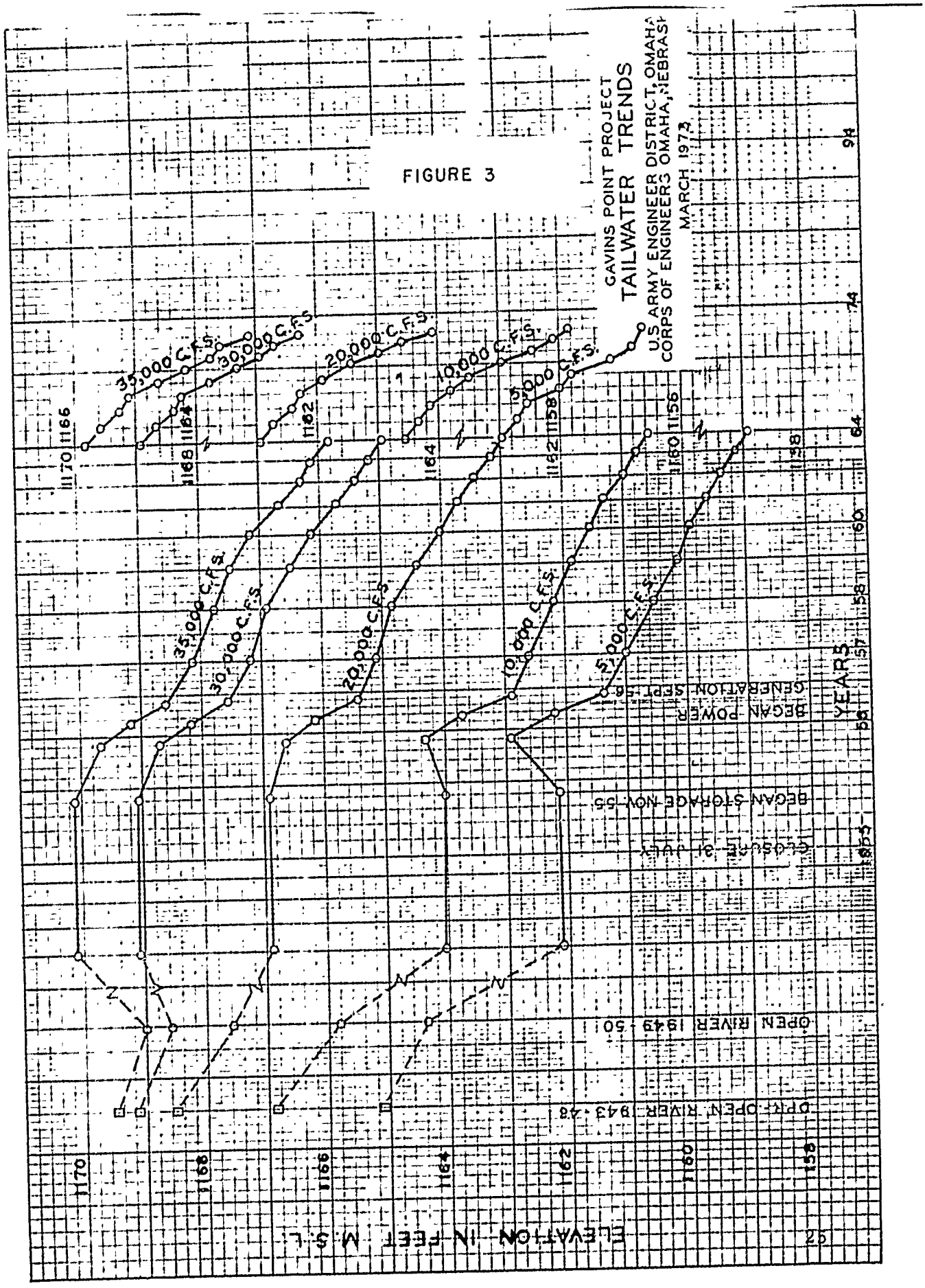


FIGURE 3
GAVINS POINT PROJECT
TAILWATER TRENDS
U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
MARCH 1973
ELEVATION IN FEET M.S.L.
YEARS
OPEN RIVER 1943-48
OPEN RIVER 1949-50
BEGAN STORAGE NOV 55
CLOSURE 31 JULY
BEGAN POWER GENERATION SEPT 56
35,000 C.F.S.
30,000 C.F.S.
20,000 C.F.S.
10,000 C.F.S.
5,000 C.F.S.

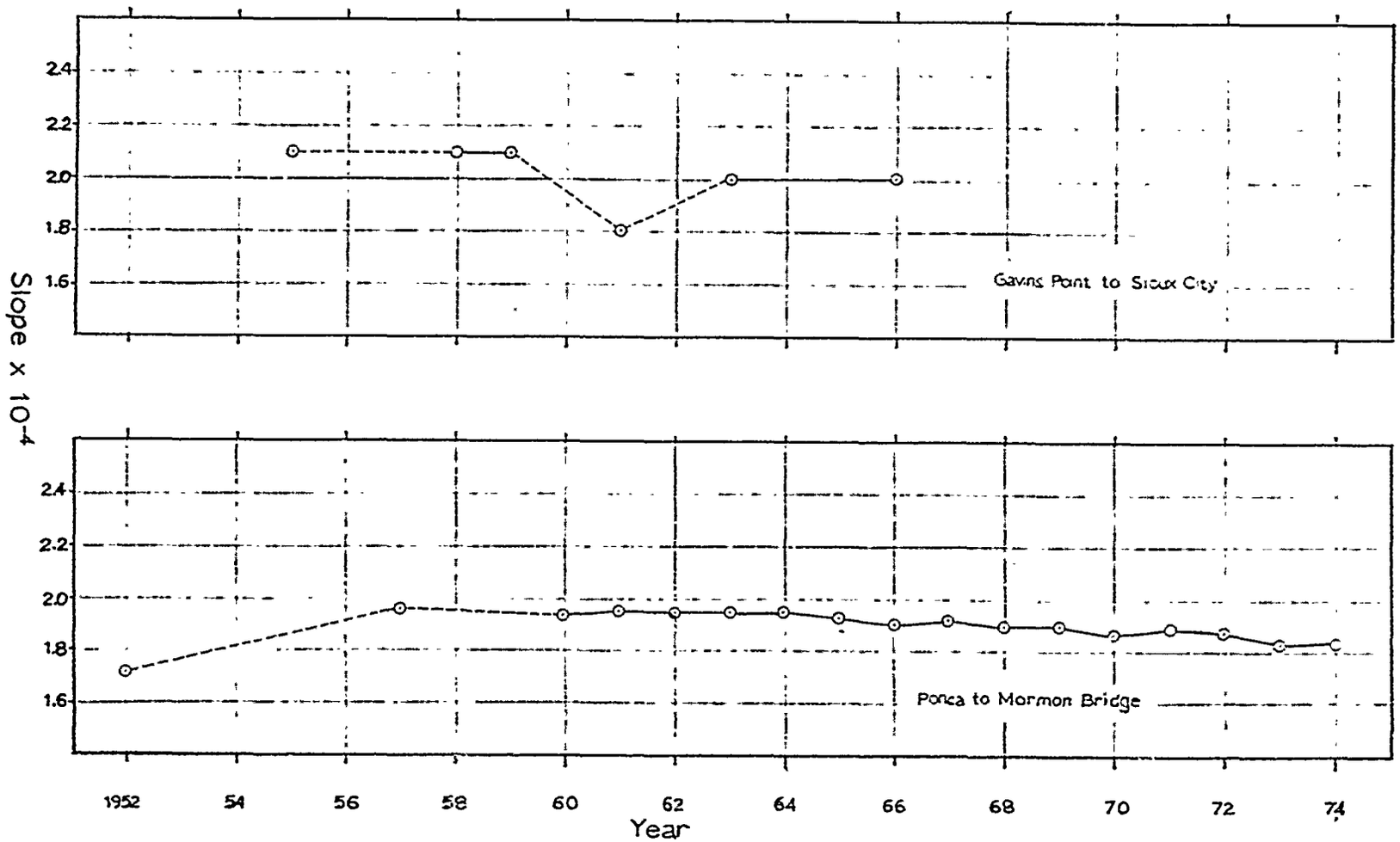


FIGURE 4. WATER SURFACE SLOPES - MISSOURI RIVER AT DISCHARGE OF 30,000 CFS.

	Yankton	Sioux City	Omaha
1950	359		718
51	348		313
52	456		782
53	359		219
54	321		302
55	966	244	217
56	802	263	257
57	1003	295	228
58	421	271	217
59	509	277	225
1960	586	275	289
61	491	266	215
62	556	287	226
63	523	293	213
64	457	292	233
65	450	329	248
66	418	296	250
67	430	308	237
68		311	248
69		296	280
1970		321	287
71		318	239
72		341	243

TABLE 15. WATER YEAR AVERAGE BED MATERIAL SIZE

D_{50}, mm x 1000

measurements made at Sioux City and Omaha are given in Appendix D including the yearly and monthly averages.

Figures 5 and 6 are summary graphs prepared by the Corps of Engineers showing the average bed material size over a 3 year period from 1971-1973 at 5 mile increments and selected reaches.

SUSPENDED SEDIMENT

Records of suspended sediment flow in the Missouri River are available at Yankton, S. Dakota, Sioux City, Iowa, and Omaha, Nebraska. The monthly and yearly average suspended sediment loads at the 3 locations are given in Table 16, 17, and 18.

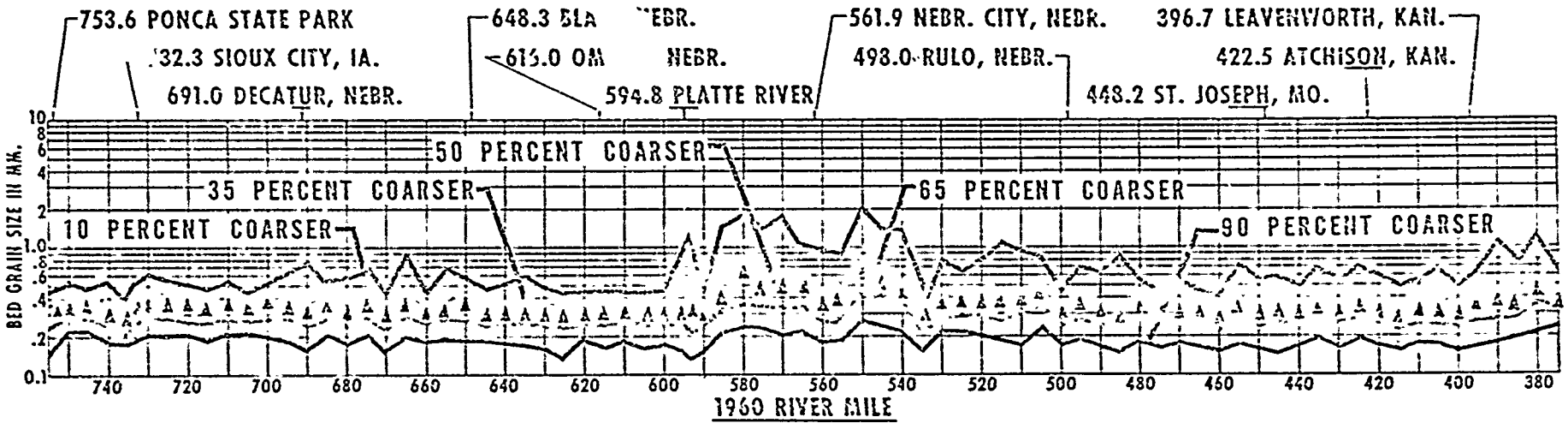
DISCHARGE HYDROGRAPHS

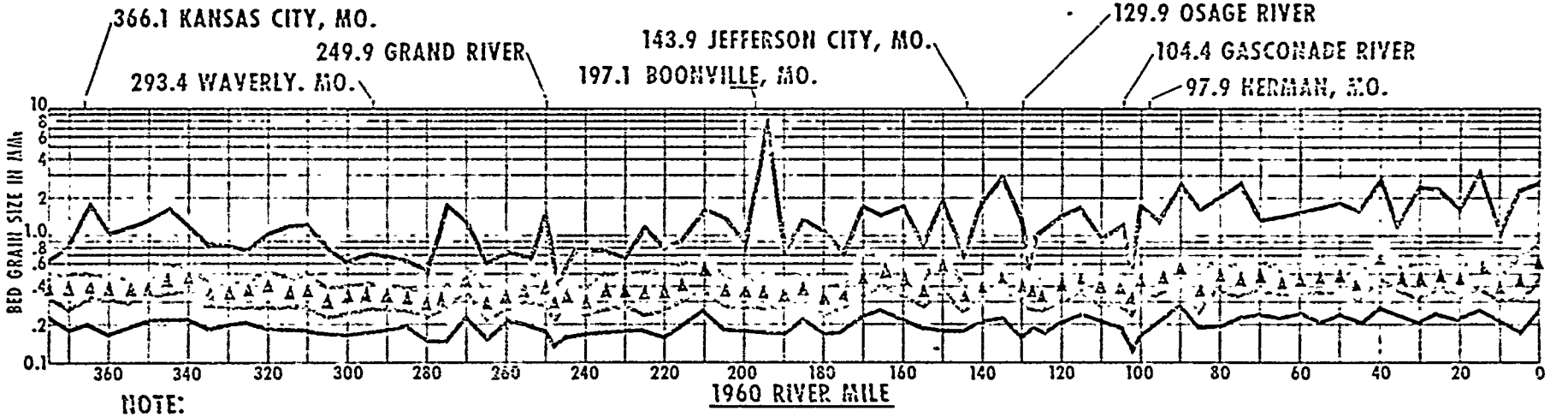
Tables 19 through 26 present the average monthly flows for the Missouri River at Yankton, Sioux City, and Omaha plus the Floyd River at James, Iowa, the Boyer River at Logan, Iowa, the Soldier River at Pisgah, Iowa, the Little Sioux River at Turin, Iowa, and the Big Sioux River at Akron, Iowa.

CHANNEL CROSS SECTION DATA

The cross sectional shape of the Missouri River has undergone several alterations during the period from 1950. The shape of the natural part of the river between Gavins Point and Ponca since 1955 can be traced through the data gathered by a degradation study done by the Corps of Engineers displayed in Appendix E. The location map for the cross sections is also presented in Appendix E.

Additional cross sectional data can be found in the summary of the discharge measurements taken at Yankton, Sioux City, Decatur, and Omaha displayed in Appendix B. The tables show changes in width, cross sectional area, and mean velocity for given discharges.





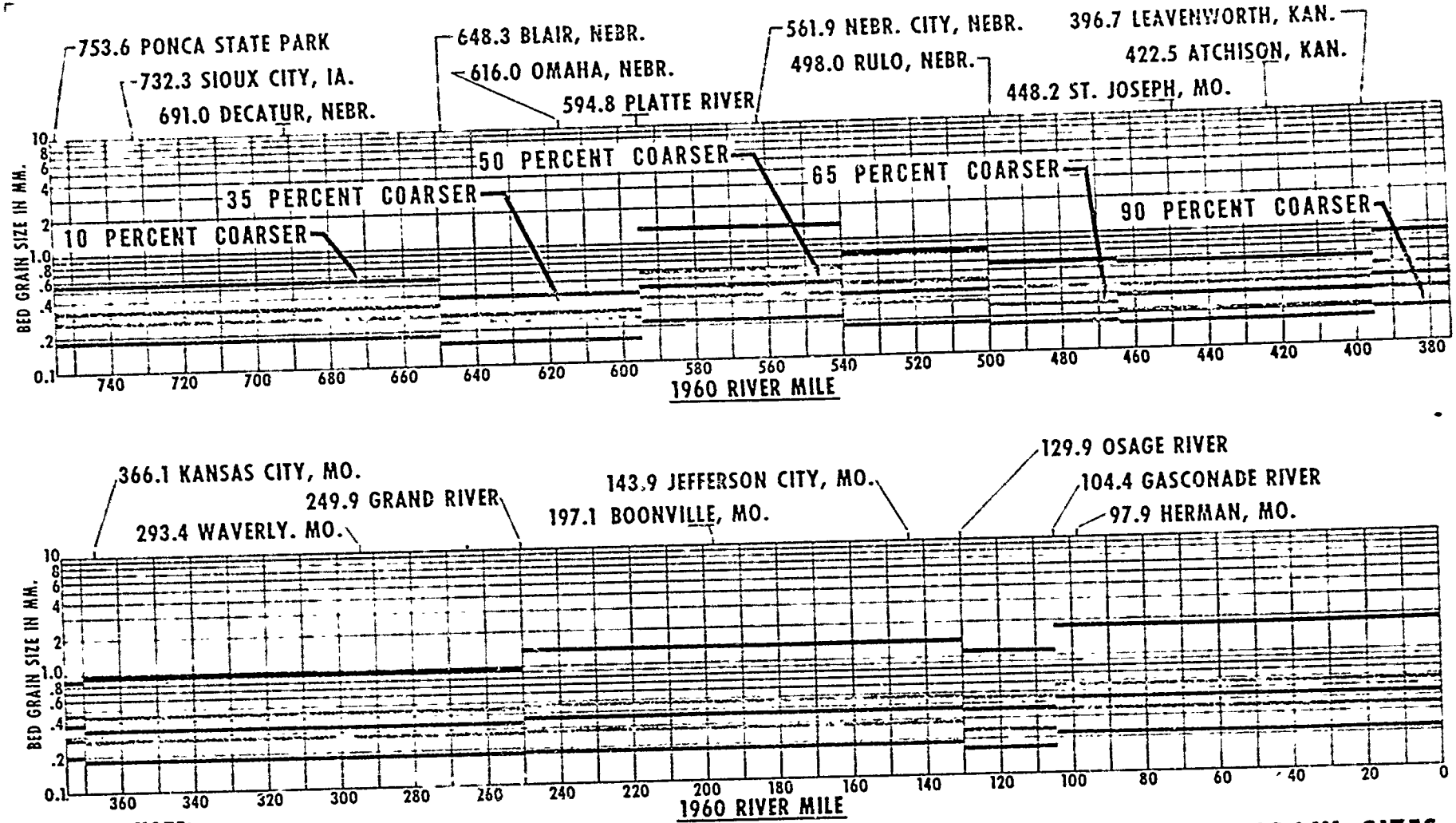
NOTE:

THE GRADATION AT EACH STATION REPRESENTS A SAMPLE COMPOSITE OF 5 TO 7 VERTICALS.

MISSOURI RIVER BED GRAIN SIZES

COMPOSITE OF 1971, 1972 & 1973 SAMPLING OBSERVATIONS

Figure 5



NOTE:

THE GRADATION AT EACH STATION REPRESENTS A SAMPLE COMPOSITE OF 5 TO 7 VERTICALS.

MISSOURI RIVER BED GRAIN SIZES FOR SELECTED REACHES

COMPOSITE OF 1971, 1972 & 1973 SAMPLING OBSERVATIONS

FIGURE 6

Water Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
1939							272490
1940	9535	6739	6050	1179	2142	8841	87230
1941	92650	15217	4705	3100	2926	8661	180010
1942	68610	29103	4835	3005	3571	64020	126790
1943	24567	26575	3555	3768	3593	54657	521490
1944	40000	39620	12584	7108	6699	23638	578050
1945	27585	38770	6661	7053	9115	259419	72115
1946	40290	18983	4171	4398	4584	43370	44482
1947	98900	28002	4147	4720	5722	47824	354750
1948	49110	39474	5777	5848	5422	129776	192240
1949	58840	49813	7612	6694	5908	132482	483990
1950	45975	20630	4873	3100	2610	67981	789180
1951	52360	35008	11212	14022	6110	29159	333390
1952	90360	57565	21943	11384	19140	92545	1070760
1953	30309	22535	2326	5589	7528	118158	30794
1954	20115	11106	7113	2883	9792	19081	22156
1955	25906	2536	1210	910	850	3038	8413
1956	8385	1409	840	749	884	4725	5089
1957	2977	659	518	414	335	359	2309
1958	1774	462	323	394	263	349	1382
1959	2596	505	511	575	539	677	2132
1960	1795	420	300	370	200	600	713
1961	1166	746	540	480	110	420	1230
1962	415	46	350	370	160	480	487
1963	965	900	380	240	39	471	1708
1964	2703	1050	360	54	160	1100	1283
1965	1057	930	114	76	73	106	529
1966	1100	840	383	354	329	455	1658
1956	1388	1007	202	164	76	655	1184
1968	1250	687	364	298	362	802	1580
1969	970	865	462	366	368	480	800

Records end in 1969

MISSOURI RIVER AT YANKTON, SOUTH DAKOTA 6-4675

MONTHLY SUMMARY OF SUSPENDED SEDIMENT LOADS IN TONS x 100

TABLE 16

eb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Annual Totals
		272490	99055	276350	141940	27315	17359	834509
		87230	122670	124800	55725	53120	14050	497081
142	8841	180010	104460	631120	93205	100390	154540	1390504
926	8661	126790	926300	614700	100530	47565	23125	2013355
571	64020	521490	44340	479140	240780	37690	53570	1493725
593	54657	578050	152440	829800	493930	86550	32590	2303069
699	23638							
		72115	22090	192670	158310	62650	34030	898468
115	259419	44482	132877	338740	17198	40690	78700	923245
584	43370	354750	146870	603000	304950	56820	37190	1692895
722	47824	192240	91570	397250	306240	122220	36990	1381917
422	129776	483990	58760	104060	54208	35235	24695	1022299
908	132482							
		789180	205730	100020	115780	67250	50912	1476742
610	67981	333390	61090	212370	113570	94309	118240	1089400
110	29159	1070760	140590	13..140	49558	37502	25848	1745345
140	92545	30794	111628	175586	35392	17451	15322	588114
528	118158	22156	21315	40258	32508	38600	38598	267528
792	19081							
		8413	11585	10219	6718	8562	9475	89424
850	3038	5089	4479	3920	4514	5069	3917	43894
884	4725	2509	2921	1779	1761	1910	1264	17409
335	359	1382	1684	2118	834	1175	1825	18586
263	349	2132	1372	1213	1809	2617	1562	16113
539	677							
		713	961	643	999	1090	1008	9102
200	600	1230	1059	1911	1297	1495	678	11136
110	420	487	1272	1307	1918	779	809	8477
160	480	1708	1159	1552	1486	871	949	10724
39	471	1283	1390	1510	1513	1520	559	13265
160	1100							
		529	1390	1482	1513	2016	1423	10712
73	106	1658	1719	1675	1358	1319	1198	12821
329	455	1184	1309	822	1010	1145	1052	10098
76	655	1580	1186	1164	1327	1208	1094	11324
362	802	800	1484	1309				7105
368	480							

-4675

ONS x 100

2

Water Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
1955	21955	3666	3823	2756	2602	7972	11276
1956	13106	4291	3276	8095	3022	16423	23158
1956	9618	3700	2564	2361	2263	2527	7538
1958	9398	2707	1424	1853	1915	3203	8639
1959	11631	4081	4252	4707	4597	5607	12679
1960	14099	6093	5995	5190	4520	13350	48259
1961	6944	4161	1220	1240	850	7603	8635
1962	3006	818	1500	1650	1300	10470	33516
1963	8903	8977	1500	940	390	2743	9442
1964	8801	9844	1800	1420	1450	5077	10765
1965	11311	11176	1652	946	769	2035	14543
1966	11201	12016	6002	4886	10801	10117	12005
1967	13577	14825	3756	2944	1763	10797	14633
1968	14386	15220	5880	5182	5252	11239	13671
1969	8643	13409	6582	5018	5164	6321	53909
1970	20167	21647	9947	5516	5879	16348	12321
1971	16947	20785	8426	4741	23468	15661	19563
1972	24736	35449	10126	12812	12412	18694	8884
1973	6773	5090	4084	6169	5848	9243	8580

MISSOURI RIVER AT SIOUX CITY, IOWA 6-4860

MONTHLY SUMMARY OF SUSPENDED SEDIMENT LOADS IN TONS x 100

TABLE 17

Mar.	Apr.	May	June	July	Aug.	Sep.	Annual Totals
7972	11276	14451	13213	11573	11651	16406	121345
16423	23158	17225	19071	14685	12281	11847	141480
2527	7538	10917	12088	12568	7033	7392	80471
3203	8639	8290	9307	10278	6579	9467	73061
5607	12679	13269	12823	8015	11317	13442	106420
13350	48259	12949	7916	7175	7785	7408	140739
7603	8635	8746	5974	7822	5751	5281	65228
10470	33516	19664	24067	12101	8391	7600	124084
2743	9442	7618	6677	8804	7066	6511	69571
5077	10765	7845	7500	6876	10341	7779	79498
2035	14543	9462	11277	8911	10521	9663	92267
10117	12005	11921	11570	11001	8823	7569	117912
10797	14633	14688	25751	11010	9659	9936	133369
11239	13671	10584	8678	8501	7818	7356	113767
6321	53909	14616	13065	12190	17391	17091	178399
16348	12321	9035	9358	12354	14041	12096	148719
15661	19563	22816	56408	15936	14341	17734	236827
18694	8884	8152	7295	7690	7676	8732	162658
9243	8580	6742	7004	8018	9235	11637	88425

S x 100

Water Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	
1939							22
1940	12313	8433	8439	1293	2886	22163	8
1941	71809	31426	10048	5113	3957	39759	19
1942	97460	46640	8847	3528	3604	94678	14
1943	33100	33090	3987	4406	8211	73243	43
1944	41100	40185	13985	10359	20809	82595	40
1945	32555	46200	9383	7192	23660	312325	14
1946	55030	25029	6992	4956	16744	76940	5
1947	129030	40510	6540	9382	14615	57720	38
1948	57670	47380	6932	7462	13462	200100	19
1949	67690	68377	11536	7307	9864	222850	37
1950	42448	26930	5839	3312	3215	98442	55
1951	71770	54387	11751	17510	14701	155878	43
1952	110790	85120	36643	12115	51680	97520	62
1953	45160	36019	9068	5962	15935	131839	5
1954	26705	11801	9008	2327	12318	38407	3
1955	31050	6586	4780	3046	3571	23062	4
1956	29152	9536	3427	2360	2080	27370	2
1957	25551	4859	2286	2241	3360	3951	1
1958	30085	7539	3695	3288	7193	8654	2
1959	21773	5280	4074	3882	2732	6612	2
1960	23618	8305	4478	2840	3470	14500	9
1961	19446	14111	4120	4330	3480	28000	2
1962	11261	3198	2870	3140	3190	70958	6
1963	26036	20538	2630	2580	1930	16236	2
1964	17685	13000	3270	2820	2970	6030	4
1965	23606	18000	3700	3400	3450	23000	8
1966	34321	20882	10243	9000	26569	15536	2
1967	23507	22600	5457	4813	3200	16973	4
1968	27110	20527	7085	6200	8800	20000	4
1969	23698	17003	5978	6450	9400	33309	8
1970	21947	17948	8728	5386	6633	30502	
1971	17315	18675	8223	6026	21371	40271	
1972	22976	23871	13891	21513	11361	53995	
1973	11189	12914	6841	6031	9480	12662	

MISSOURI RIVER AT OMAHA, NEBRASKA 6-6100

MONTHLY SUMMARY OF SUSPENDED SEDIMENT LOADS IN TONS x 100

TABLE 18

Mar.	Apr.	May	June	July	Aug.	Sep.	Annual Totals
	220980	75115	297350	213580	50864	17399	875288
22163	84740	134910	219220	155910	103870	29220	783397
39759	195110	94250	556900	127360	77030	181930	1394692
94678	149380	860430	696200	213590	80440	49320	2304217
73243	437790	100980	585450	352900	89050	74970	1796177
82595	409500	189620	791560	664700	201600	50780	2516783
312325	145570	142000	423650	284130	100020	38604	1565378
76940	57265	150585	351000	184110	55115	107250	1091016
57720	383000	172710	515450	317780	73040	41960	1761739
200100	190040	103730	353340	322050	141070	47460	1500796
222850	373940	30680	162480	90240	48230	62310	1205584
98442	556700	309510	182460	182260	111440	72800	1595519
155878	437950	243550	496650	250540	255219	184670	2194588
97520	623460	130360	170780	155530	54720	51910	1579628
131839	58803	121860	251270	62777	39900	32499	805354
38407	38010	49732	93904	38804	25813	26026	372925
23062	43220	30118	24326	36662	22462	26040	254924
27370	28642	30959	21273	31698	23125	25500	233121
3951	13338	33401	99984	41582	22781	26591	279922
8654	24904	22785	20020	25819	19038	17934	191948
6612	23436	83494	60169	25065	29468	22000	288036
14500	94295	47894	35834	26192	28729	18740	308895
28000	26881	31391	48912	29627	23733	22208	256239
70958	61332	83724	68860	65141	25886	35713	435274
16236	26061	30629	109018	23488	24834	17449	301589
6030	43537	93105	25723	21114	16887	16503	262544
23000	80425	73344	43988	19964	24002	49149	366024
15536	23337	20152	34452	21214	23963	17842	256511
16973	23500	17595	136540	27070	19247	16258	318760
20000	23393	15662	33828	17086	14231	12951	206873
33309	82598	31934	48565	50324	47209	31833	388301
30502	19244	23562	26269	14904	15976	17774	208873
40271	21034	22159	58642	26582	21393	18065	279755
53995	22238	21932	18694	40130	15612	18670	284883
12662	13271	58932	28942	14493	16447	12184	213386

x 100

2

Year	Month					
	Jan.	Feb.	Mar.	Apr.	May	June
1951	16910	14390	19770	63150	33270	51750
1952	14850	22740	29930	168000	48220	49100
1953	12980	14970	33880	25980	36970	65010
1954	10240	14650	20730	25530	26760	23960
1955	8926	9196	15320	26230	30920	19970
1956	8487	9714	23810	28900	28960	29770
1957	9222	8466	8085	17740	26680	22890
1958	8803	8695	9624	23280	26300	27950
1959	10240	10530	11170	24760	22550	24510
1960	8999	8207	10770	13970	18870	20770
1961	9467	7869	9421	22520	23390	21780
1962	8997	7720	9739	10960	18390	18790
1963	8222	5464	10580	25990	26560	25220
1964	6181	6987	13080	24190	24970	26610
1965	7673	7896	8819	19320	24230	23720
1966	16330	16580	17990	25770	27670	29810
1967	11100	7837	18300	29150	32280	24060
1968	14710	16980	23350	32450	32550	33490
1969	16610	17510	18730	23210	34330	34650
1970	15920	17110	24050	28750	30120	34930
1971	15770	17390	25360	35100	44560	48640
1972	19920	20060	26580	40650	38160	41470
1973	21670	20350	20100	23000	28320	29410
1974	17100	17990	22590	30050	30100	30260

Table 19. Mean Monthly Discharge

Missouri River at Yankton, S. Dakota

May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
		39670	41010	43650	43070	37730	13560
		30780	28820	28280	28780	23000	8935
33270	51750	37790	29420	33000	32620	17720	13320
48220	49100	29650	30510	31600	28880	11630	11160
36970	65010						
26760	23960	28330	32070	34550	32190	11840	9058
		30080	33100	33940	25890	11810	9196
30920	19970	27510	30600	28380	28120	11800	8351
28960	29770	25970	28220	28910	29980	9643	9375
26680	22890	27270	29790	30480	28110	10670	9372
26300	27950						
22550	24510	25760	27870	27360	27200	18810	9311
		28060	27490	27560	12580	5892	8344
18870	20770	24090	22710	25030	25380	22900	3545
23390	21780	30090	28970	27860	29070	24060	8466
18390	18790	28720	31560	27010	29440	25910	9200
26560	25220						
24970	26610	26690	31670	28270	29570	27840	16970
		33440	31810	30810	31930	29050	12340
24230	23720	31000	15630	15540	34870	30630	16570
27670	29810	35500	34180	31790	30440	32090	17690
32280	24060	34690	53520	52880	46250	40370	19240
32550	33490						
34330	34650	40760	45230	41920	41950	40450	19800
		48340	48600	48750	50560	52380	27110
30120	34930	15170	48120	48500	50350	46770	22490
44560	48640	31150	31810	31640	26820	28370	17200
38160	41470	35730	35340	35090			
28320	29410						
30100	30260						

Year	Month						
	Jan.	Feb.	Mar.	Apr.	May	June	Ju
1951	16590	15290	24310	75830	40090	60970	507
1952	13320	26730	32780	186900	59570	54070	371
1953	13210	15850	38290	31120	42480	65070	397
1954	10570	16050	24800	27160	28700	32620	310
1955	8820	9160	19090	25640	29330	29290	283
1956	9005	9359	23740	29820	29580	30450	304
1957	8690	9061	9135	17450	27520	26780	300
1958	9149	9696	10130	24510	26810	27940	268
1959	10240	10870	11700	25840	25430	25270	270
1960	9090	8772	13330	42400	24070	23270	27
1961	9387	8086	14660	23480	26070	24310	29
1962	8887	8436	14190	36680	23820	31830	33
1963	8939	6293	11190	26090	27030	26380	30
1964	7316	7712	13150	26260	26270	27510	29
1965	8606	8654	10500	27090	28630	29140	29
1966	16860	21140	22140	28830	29900	32130	33
1967	11340	9696	19380	31470	33310	30010	32
1968	14720	17560	24040	32890	32810	33780	34
1969	16520	18410	21130	50970	41150	37970	38
1970	15420	18830	28680	33120	33370	37270	40
1971	15440	23980	30300	37350	45000	54190	49
1972	19810	20640	32080	43030	45850	47730	47
1973	22770	22990	32110	27550	30280	30880	32
1974	17950	19510	23980	30930	30470	32270	35

Table 20. Mean Monthly Discharge

Missouri River at Sioux City, Iowa

May	June	July	Aug.	Sep.	Oct	Nov.	Dec.
0090	60970	50750	45160	49410	45340	38890	14560
9570	54070	37130	30350	29840	29690	24720	9077
2480	65070	39710	32990	33610	32680	18810	13420
8700	32620	31050	30750	31280	29740	12330	11270
9330	29290	28300	29450	33190	31900	12220	9460
9580	30450	30460	33520	33650	27000	12250	9217
7520	26780	30060	31810	28420	29190	12660	8445
6810	27940	26890	27390	28380	29620	10970	9464
5430	25270	27040	29660	30580	27880	11530	9187
4070	23270	27220	30590	29160	27460	20080	9177
6070	24310	29310	29120	28620	14350	6951	8271
3820	31830	33120	25640	25790	26200	24290	8733
7030	26380	30230	30030	28310	29540	25640	8377
6270	27510	29470	32420	28190	30050	27840	9435
8630	29140	29230	32260	29830	31440	29350	18450
9900	32130	33990	32650	31940	32950	31030	13530
3310	30010	32590	35630	35330	34290	31280	16920
2810	33780	34840	33940	31800	31940	32300	16940
1150	37970	38580	52970	53030	46360	40400	21340
3370	37270	40120	44850	41590	42210	41400	22480
5000	54190	49290	48760	48970	50540	53720	29040
5850	47730	47400	49530	49250	50720	48400	23580
0280	30880	32830	32160	31930	27940	29460	18480
0470	32270	35570	35520	24890			

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Year	Month						
	Jan.	Feb.	Mar.	Apr.	May	June	Ju
1951	18430	16760	31710	88520	48960	67560	57
1952	14790	31790	35470	188800	61660	55830	41
1953	13050	17460	40890	33890	43470	71450	43
1954	9123	16520	26990	28620	29860	42520	33
1955	9067	10410	21470	29220	30100	30290	31
1956	9219	9784	24930	30250	30230	30560	30
1957	8521	8981	10170	16480	28020	31640	31
1958	9578	10400	12090	25080	26550	28130	27
1959	9789	10590	12730	24630	28720	31290	28
1960	8690	9720	13510	54570	29860	27590	28
1961	10050	11130	23490	25670	26450	26890	29
1962	9161	10610	25650	47030	28700	37830	39
1963	9695	8162	14460	26910	28250	31610	30
1964	8425	8966	13080	27100	29330	28190	28
1965	9687	11050	18250	42820	31760	31480	30
1966	17280	25050	22510	30560	30960	33030	34
1967	11060	10180	21470	32430	33520	43060	33
1968	15020	17130	23560	32900	33020	34950	34
1969	15550	18410	25880	66320	44730	42140	44
1970	16030	21000	30530	34520	34510	37940	40
1971	14450	28160	38560	39620	45420	59260	50
1972	18810	22190	35130	44760	49450	49680	49
1973	26170	24590	42340	30690	34130	33330	34
1974	18670	21930	25870	33570	35190	35640	35

Table 21. Mean Monthly Discharge

Missouri River at Omaha, Nebraska

May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
18960	67560	57960	54140	54180	45790	39920	15840
51660	55830	41700	30660	30280	30330	26700	998
13470	71450	43880	34690	33910	32430	20500	13950
29860	42520	33440	32310	32110	32340	14510	12710
30100	30290	31550	28660	34400	32140	13950	9047
30230	30560	30830	33400	33590	27930	13460	8831
28020	31640	31060	30620	29310	30150	14900	9322
26550	28130	27150	27280	28290	29430	12430	9251
28720	31290	28300	30380	31030	28420	13890	10090
29860	27590	28220	31570	29580	27990	22220	10260
26450	26890	29230	29770	29590	16920	8324	8296
28700	37830	39870	28060	30350	27550	25750	9855
28250	31610	30730	31100	29280	29630	27160	9245
29330	28190	28990	32920	29600	30340	28700	9631
31760	31480	30060	32720	31910	32730	30300	18960
30960	33030	34340	33690	32460	33190	31870	13750
33520	43060	33610	35860	35350	34510	31760	17100
33020	34950	34950	34460	32550	33860	32420	18160
34730	42140	44950	53860	54700	47210	41190	22100
34510	37940	40240	44220	42060	42590	42550	23240
35420	59260	50940	48830	49240	51220	54840	30670
39450	49680	49610	50430	50440	51740	51490	26210
34130	33330	34870	33200	33150	30790	31540	20650
35190	35640	35890	36470	35570			

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Year	Month					
	Jan.	Feb.	Mar.	Apr.	May	June
1951	48.2	70.2	1367	9040	2330	2551
1952	300	1466	3322	11530	2336	1750
1953	127	122	2387	1275	2224	3476
1954	115	1128	3556	1329	955	3655
1955	161	84.6	1206	651	381	234
1956	33.3	32.6	141	385	235	275
1957	39.8	52	670	576	411	3794
1958	127	98.9	382	689	370	234
1959	22.5	14.1	265	172	568	1224
1960	121	80	2021	10830	1482	825
1961	92.7	489	2842	683	689	525
1962	67.6	363	4059	10950	2513	3686
1963	101	126	609	611	487	565
1964	63.9	65.2	168	1012	874	277
1965	30.5	56.4	574	4250	2237	2268
1966	140	2399	1581	802	643	379
1967	71	75	1540	1098	354	1879
1968	42.8	63.6	165	223	202	175
1969	110	114	262	20890	2052	1197
1970	121	331	2262	2380	1631	1481
1971	104	1074	1877	1145	490	2085
1972	121	82	2964	1122	2661	3256
1973	721	598	5652	1795	959	770
1974	108	238	936	634	469	494

Table 22. Mean Monthly Discharge

Big Sioux at Akron, Iowa

June	July	Aug.	Sep.	Oct.	Nov.	Dec.
2551						
1750	3101	1465	1446	880	636	505
3476	1555	582	374	198	178	138
3655	1201	1789	510	269	267	245
234	226	468	403	306	272	180
	136	70.7	40.7	55.0	51.1	32.7
275						
3794	409	507	130	72	96.8	68.1
234	1964	549	445	231	283	225
1224	128	53.8	37.3	32.9	47.9	32.5
825	123	228	176	117	150	153
	399	247	530	284	206	131
525						
3686	407	212	129	138	278	121
565	2837	1162	622	374	284	182
277	314	830	278	247	179	96
2268	217	104	381	158	125	56.1
	977	256	228	632	314	241
379						
1879	156	154	249	203	167	109
175	698	200	114	88	92	81
1197	193	79.3	98.8	747	468	213
1481	3239	639	323	261	227	145
	584	244	185	279	337	179
2085						
3256	973	197	123	131	234	176
770	1676	1044	469	363	614	344
494	464	215	165	443	2711	191
	494	142	147	96		

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Year	Month					
	Jan.	Feb.	Mar.	Apr.	May	June
1951	17.3	76.9	1306	895	908	768
1952	279	701	945	597	473	490
1953	75	143	408	302	345	521
1954	28	105	85	101	278	1550
1955	55	35	305	186	67.2	48
1956	12	12	36	29	43	49
1957	5	7	26	20	45	260
1958	26	170	105	96	51	148
1959	3	4	68	52	868	552
1960	58	35	68	572	445	321
1961	33.2	156	1056	244	171	532
1962	54	173	1448	515	504	575
1963	96	100	501	148	259	904
1964	44	62	57	117	393	153
1965	19	96	467	1725	262	229
1966	337	1453	796	1420	984	917
1967	69.5	111	657	435	298	4991
1968	46	81	184	157	118	315
1969	269	280	2060	9610	2259	2696
1970	202	458	1542	1900	1564	820
1971	253	3353	4359	2585	966	3600
1972	103	74	1530	546	2215	1383
1973	836	853	5414	2646	2278	2174
1974	647	1255	1383	1500	1763	1956

Table 23. Mean Monthly Discharge

Little Sioux at Turin, Iowa

May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
908	768	795	1230	1034	426	264	221
473	490	888	246	142	113	92	81
345	521	97.5	192	55	49	55	43
278	1550	222	154	102	251	108	89
67.2	48	308	44	24	25	23	15
43	49	33	13	5	9	17	7
45	260	195	27	47	61	103	65
51	148	64	50	19	14	14.6	6
868	552	178	95	46	52	46	82
445	321	200	237	197	85	76	55
171	532	156	213	126	118	90	75
504	575	508	562	615	258	194	125
259	904	163	108	81	67	58	39
393	153	118	61	75	39	35	26
262	229	89	46	262	1186	644	558
984	917	300	296	158	146	147	84.7
298	4991	933	279	150	125	132	98.8
118	315	181	195	372	1425	824	403
259	2696	4401	1552	799	415	358	246
564	820	299	210	151	705	1035	644
966	3600	1819	399	188	180	351	236
215	1383	1478	1066	460	466	1088	545
278	2174	1484	961	636	1379	1391	1298
763	1956	779	560	333			

Year	Month						
	Jan.	Feb.	Mar.	Apr.	May	June	July
1951	16	25	1035	1254	825	942	1053
1952	187	970	1558	908	280	230	592
1953	37	38	390	267	446	2187	175
1954	36	247	584	173	164	1138	179
1955	39	24	173	181	113	50	57
1956	6	7	39	33	34	17	25
1957	3	9	30	31	23	90	198
1958	11	80	41	65	43	61	14
1959	2	2	54	19	138	190	24
1960	17	8	996	926	400	150	51
1961	19	89	1081	179	130	241	73
1962	13	56	1912	946	253	484	174
1963	21	23	125	63	35	114	32
1964	6	10	22	33	76	20	57
1965	7	14	399	1424	209	233	122
1966	28	628	113	161	86	136	38
1967	10	10	283	41	45	549	92
1968	7	12	22	20	15	14	45
1969	14	15	332	2715	227	310	398
1970	16	151	456	299	230	175	59
1971	21	954	199	155	68	1447	186
1972	13	22	517	97	398	376	257
1973	359	181	1275	277	179	266	437
1974	46	84	139	184	145	294	95

Table 24. Mean Monthly Discharge

Floyd River at James, Iowa

May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
		1053	1151	1353	437	285	215
825	942	592	124	90	53	42	43
280	230	175	288	73	58	67	73
446	2187	179	99	69	83	59	42
164	1138	57	17	11	17	12	7
113	50						
		25	36	6	6	9	5
34	17	198	38	37	24	36	28
23	90	14	6	3	5	5	3
43	61	24	63	9	12	14	19
138	190	51	190	121	59	39	19
400	150						
		73	91	48	54	41	25
130	241	174	112	163	76	58	32
253	484	32	33	19	13	13	9
35	114	57	15	96	24	15	8
76	20	122	34	53	213	87	61
209	233						
		38	28	19	21	14	12
86	136	92	46	20	16	21	16
45	549	45	23	47	153	72	32
15	14	398	136	89	58	56	38
227	310	59	35	56	70	75	38
230	175						
		186	60	40	37	45	28
68	1447	257	125	53	57	119	156
398	376	437	165	81	156	128	66
179	266	95	120	61			
145	294						

Year	Month					
	Jan.	Feb.	Mar.	Apr.	May	June
1951	19	330	1784	488	1278	1764
1952	672	622	822	668	533	1087
1953	99	495	471	421	441	507
1954	20	168	100	301	258	1064
1955	63	40	614	215	81	70
1956	8	11	52	25	227	33
1957	9	51	57	23	143	1178
1958	62	299	170	128	83	129
1959	7	42	211	110	690	586
1960	59	58	610	733	602	348
1961	33	174	635	220	216	648
1962	104	259	1819	632	703	838
1963	121	211	691	210	329	487
1964	56	63	115	364	770	455
1965	53	444	1444	1151	827	503
1966	134	242	219	216	212	415
1967	26	52	117	74	46	1649
1968	23	46	68	78	40	410
1969	117	129	1604	1091	370	566
1970	45	158	267	208	257	127
1971	18	1209	1022	185	146	265
1972	25	211	410	91	317	575
1973	692	541	1448	1083	1075	746
1974	435	1194	453	455	1508	554

Table 25. Mean Monthly Discharge

Boyer River at Logan, Iowa

y	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
8	1764	1088	1636	775	684	362	214
3	1087	921	355	194	141	139	135
1	507	155	160	39	37	46	64
8	1064	119	244	107	224	108	107
1	70	321	52	48	23	13	11
7	33	101	135	53	11	31	16
3	1178	213	51	72	93	113	114
3	129	406	86	39	24	31	12
0	586	169	84	66	63	102	117
2	348	297	244	158	80	80	59
6	648	234	162	132	156	142	123
3	838	481	498	698	281	203	130
9	487	150	252	168	90	89	55
0	455	317	353	147	95	88	63
7	503	211	110	587	382	269	218
2	415	166	107	72	60	58	37
6	1649	266	94	81	62	60	52
0	410	107	95	138	384	196	144
0	566	531	244	121	95	91	67
7	127	60	52	37	87	83	59
6	265	138	40	26	60	66	43
7	575	629	180	1218	257	501	565
5	6	942	308	751	796	558	442
8	654	295	322	157			

2

Year	Month						Jul
	Jan.	Feb.	Mar.	Apr.	May	June	
1951	14	287	814	329	332	700	348
1952	431	272	384	248	269	531	368
1953	60	199	207	167	173	212	80
1954	26	130	59	120	194	462	80
1955	25	28	271	70	35	35	4
1956	7	9	40	15	74	22	7
1957	6	30	28	13	14	202	12
1958	24	169	55	54	29	69	16
1959	3	24	118	47	306	157	5
1960	17	24	257	315	249	197	11
1961	25	168	349	84	77	181	5
1962	35	56	682	179	337	368	28
1963	68	125	332	104	117	366	10
1964	39	46	59	109	425	231	11
1965	32	253	797	526	246	223	9
1966	44	141	108	83	84	136	6
1967	18	44	74	40	26	926	12
1968	19	39	47	37	24	218	3
1969	37	46	689	220	102	158	27
1970	37	88	150	89	85	47	2
1971	10	653	520	43	42	103	4
1972	7	124	145	50	101	112	27
1973	178	168	498	259	243	198	19
1974	105	176	165	122	420	226	22

Table 26. Mean Monthly Discharge

Soldier River at Pisgah, Iowa

ay	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
32	700	348	562	366	233	159	98
69	531	368	166	95	81	78	73
73	212	80	234	33	30	54	47
94	462	86	90	70	66	45	43
35	35	43	18	17	12	17	8
74	22	77	37	7	10	17	10
14	202	126	30	50	37	50	29
29	69	161	49	17	11	13	6
06	157	52	58	24	32	29	41
49	197	110	114	87	52	43	36
77	181	58	100	73	71	58	45
37	368	282	464	279	141	95	78
17	366	104	191	72	56	58	41
25	231	112	95	76	45	45	31
46	223	99	61	183	98	79	87
84	136	61	55	34	30	32	19
26	926	127	52	33	35	35	29
24	218	34	45	39	141	48	42
02	158	270	113	55	46	43	32
35	47	23	22	21	39	36	26
42	103	47	14	14	30	25	18
01	112	270	63	187	58	115	138
43	198	198	111	161	198	137	109
20	226	226	115	166	61		

RESULTS

The available data for the Missouri River reach between Gavins Point Dam and Omaha, Nebraska reveal several major impacts on the river which have occurred since 1950. The impacts are attributable to a combination of changes made by man and nature.

SEDIMENT

The history of the yearly sediment load at Yankton, S. Dakota, and Omaha, Nebraska (Tables 16-18) shows a definite decrease in load for the years between 1952 and 1953. The reduction in load resulted from the construction of Gavins Point Dam which began in 1952 and ended in 1955. Before 1953 the average annual suspended load at Yankton, South Dakota was 137,906,830 tons per year. Following the construction of Gavins Point Dam or from 1953 on, the average has dropped to 6,702,000 tons per year or approximately 5 percent of the previous average. A similar trend occurred at Omaha, Nebraska where the reduction in yearly averages before and after 1953 was from 163,765,123 tons per year to 32,507,911 tons per year. Although the data is not available at Sioux City, Iowa for those years, the same trend exists there since it lies between the 2 other locations.

The bed material size records at Yankton, South Dakota, Table 15, show a large increase from 1954 to 1955. This phenomenon would be expected since the impoundment of the water in the dam would allow sediments to settle out and result in relatively clear water releases from the dam. This clear water would have a large sediment transport capacity, and since the only available sediment loads are from the perifery of the river channel, the smaller bed materials would be picked up into suspension and result in larger bed material sizes being sampled as indicated in table 15.

Therefore, the construction of Gavins Point Dam greatly reduced the inflow of suspended sediments into the reach below the dam and subjected the bed materials in the downstream reach to larger transport capacities, resulting in degradation and larger bed

material sizes.

The extent of degradation below the dam to Ponca is seen by the cross-sections displayed in Appendix E. The thalweg elevations, which are one indicator of degradation, at two of the stations, 843.8 and 801.4, have dropped 6.8 feet and 11.2 feet respectively in 14 years from 1960 to 1974. Partially as a result of the amounts of degradation at Yankton and Sioux City, the U.S.G.S. has lowered the datum used, by a 20-foot increment, during the 1969 - 1970 period.

GEOMETRY

The data gathered for the period under consideration indicate a significant change in both the river alignment and channel geometry.

The data available on channel realignment given in Table 2 show that 41 of the 51 bends which existed in 1950 were altered in alignment by 1970. The reach of Missouri River between Sioux City, Iowa, and Omaha, Nebraska, was transformed from a sometimes braided channel to a single sinuous channel.

The channel realignment activity was coupled with channel narrowing to obtain a relatively uniform channel width throughout the reach from Ponca to Omaha, Nebraska. The present channel has a relatively uniform width between 600 and 700 feet. The 1950 channel had widths of near 1000 feet in certain reaches, so the amount of channel constriction has been up to 400 feet in places.

The slope of the channel between Ponca and Omaha, Nebraska, was substantially increased from 0.000172 ft/ft. to .000196 ft/ft. in the years between 1950 and 1957 because of some of the cutoffs which were made (see Figure 4). Since 1957 the slope has been decreasing; however, it has not reached the 1950 value.

The period from 1950 to 1970 saw the reach of Missouri River between Gavins Point Dam and Omaha, Nebraska, undergo major physical changes. The channel length was shortened by approximately 12 miles, the alignment was extensively changed and stabilized, the width was constricted and made essentially uniform, and the slope was increased but has since decreased due to the increased sediment transport capability of the river below Gavins Point.

FLOW QUANTITIES

Construction of the dams and reservoirs from Gavins Point and upstream has produced a means of flood control for the downstream channel which regulates the amount of water entering the channel below Gavins Point. The flow data in Table 19 show a large decrease in peak flows at Yankton, South Dakota. The flow timing can be altered to extend the navigation season and provide a more constant flow throughout the system.

WATER TEMPERATURE

The available data show no significant changes in water temperature between 1950 and 1970. Some effect due to the stored water at Gavins Point could be present; however, the available data does not cover the entire period from 1950.

CONCLUSIONS

In the period since 1950, the Missouri River has undergone extensive alterations. Subsequent to the 1952 flood, a major channel modification and construction period began. The results of this construction era produced several major impacts on the Missouri River between Gavins Point Dam and Omaha, Nebraska.

1. The suspended sediment quantities in the reach were reduced due to the construction of Gavins Point Dam.

2. Because of the reduced suspended sediment quantities being introduced at the upstream end of the reach, transport capacity was available to move material from the bed of the river below Gavins Point Dam and degrade the channel to some point downstream of Sioux City.

3. The construction of dams upstream of Yankton provided a measure of flood control which can reduce the flood peaks and alter the timing of flows in the channel.

4. Channel modifications have produced an essentially uniform sinuous channel 600 to 700 feet in width from Ponca to Omaha, Nebraska. The structure density (number of bridges or other structures per unit distance in the flow path of the river) in this reach has increased about 285 percent since 1950 and a stable channel has been formed.

5. The natural tendency of the slope of the channel has been in the direction of a decrease, following either dam construction or a short-term local slope increase caused by construction of a cutoff.

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Because of the large change in the flow and channel characteristics in the reach from Gavins Point to Omaha, the channel has had to and is still adjusting its slope and cross-sectional shape in order to accommodate the inflows of sediment and water to the reach. The impacts on the river which were first felt in the early 1950's will still produce an effect on the reach until the factors of slope, grain size, and the transport of sediment reach a dynamic equilibrium.